

# **OPTION A: ANALYTICAL CHEM**

## **A6 — ATOMIC ABSORPTION SPECTROSCOPY**

IB Chemistry

TAD05



# A6 – Atomic Absorption Spectroscopy

- A.6.1 State the uses of AA spectroscopy. (1)
  - *Aim 8: Include uses such as the identification of metals in water, blood, soils and foods.*
- A.6.2 Describe the principles of atomic absorption. (2)
- A.6.3 Describe the use of each of the following components of the AA spectrophotometer: fuel, atomizer, monochromatic light source, monochromatic detector and readout. (2)
- A.6.4 Determine the concentration of a solution from a calibration curve. (3)
  - *Aim 7: Details about the instruments used can be found on the Internet.*



# Uses of AA

## A.6.1 State the uses of AA spectroscopy. (1)

- AAS is used for the
  - Quantitative identification of trace levels of metals
  - Analyze soil and water samples
  - Clinical determinations to measure  $[\text{Na}^+]$ ,  $[\text{K}^+]$ ,  $[\text{Ca}^{2+}]$  in blood plasma and serum
  - Identify impurities in alloys and metals
  - Presence of metals in used oils due to corrosion and wear
  - Detect and measure trace elements in food



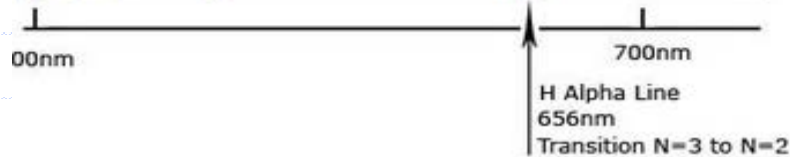
# Atomic Absorption vs Emission

Hydrogen: Absorption (top) and Emission (bottom)

Hydrogen Absorption Spectrum

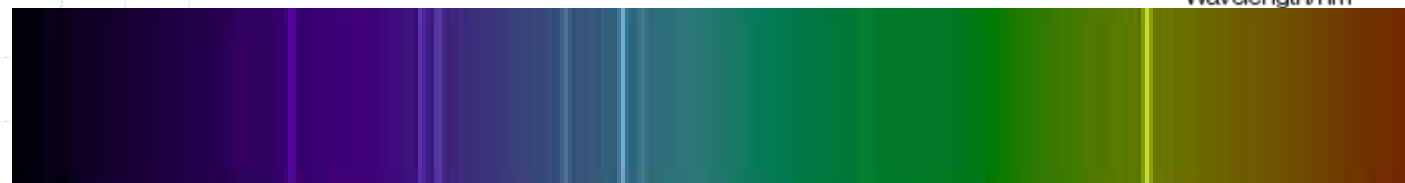
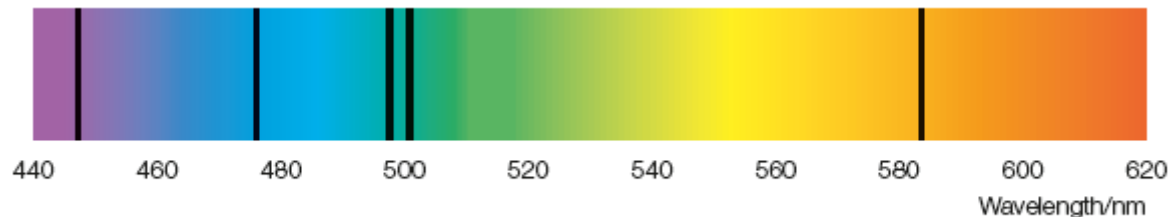


Hydrogen Emission Spectrum



The absorption and emission spectra are equal and opposite of each other

Helium: Absorption (top) and Emission (bottom)



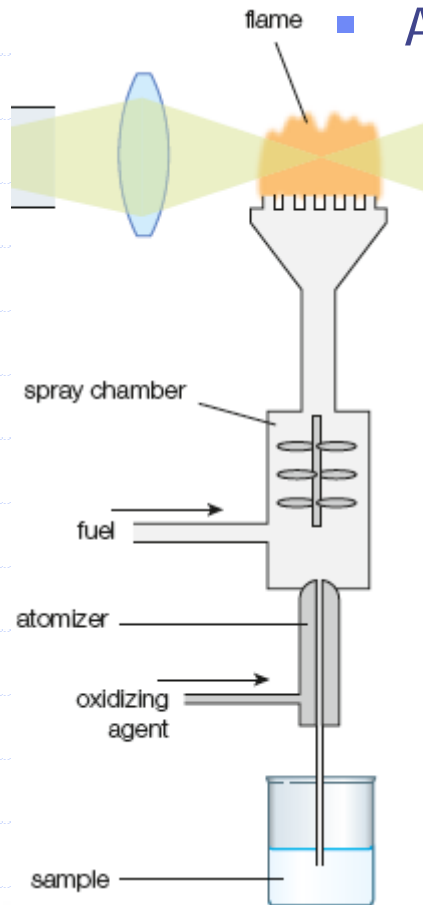
# Principles of AA

## A.6.2 Describe the principles of atomic absorption. (2)

- **Atomic Emission Spectroscopy** was discussed in Topic 02 where energy was supplied (via flame or circuit) to promote electrons of gaseous atoms to higher levels. When excited electrons return to their ground state they emit E.M. radiation of diagnostic frequencies.
- In **Atomic Absorption Spectroscopy** the sample is
  - Vaporized in a low-temperature flame
  - Fewer electrons are promoted (excited)
  - E.M. radiation is directed at the atomized sample
  - Electrons are only promoted when the specific wavelength of light for that promotion (quanta) will be absorbed
  - Light before and after the beam is compared



A.6.3 Describe the use of each of the following components of the AA spectrophotometer: fuel, atomizer, monochromatic light source, monochromatic detector and readout. (2)



## ■ Atomizer (flame atomization):

- Solution sample is drawn (by capillary action) into the apparatus and dispersed as a fine spray by the atomizer
- Then mixed with a fuel ( $C_2H_2$  – acetylene) and oxidizing agent (air) which carry it upwards into the flame
- Solvent evaporates in the lowest region of the flame and finely divided solid particles are formed
- Particles move to the hottest part of the flame, producing gaseous atoms and electron excitation (promotion)
- Atoms move to the outer edge of the flame to be oxidized prior to being dispersed into the atmosphere
- Temperature is closely controlled so that very little ionization occurs and the vapor consists largely of gaseous atoms

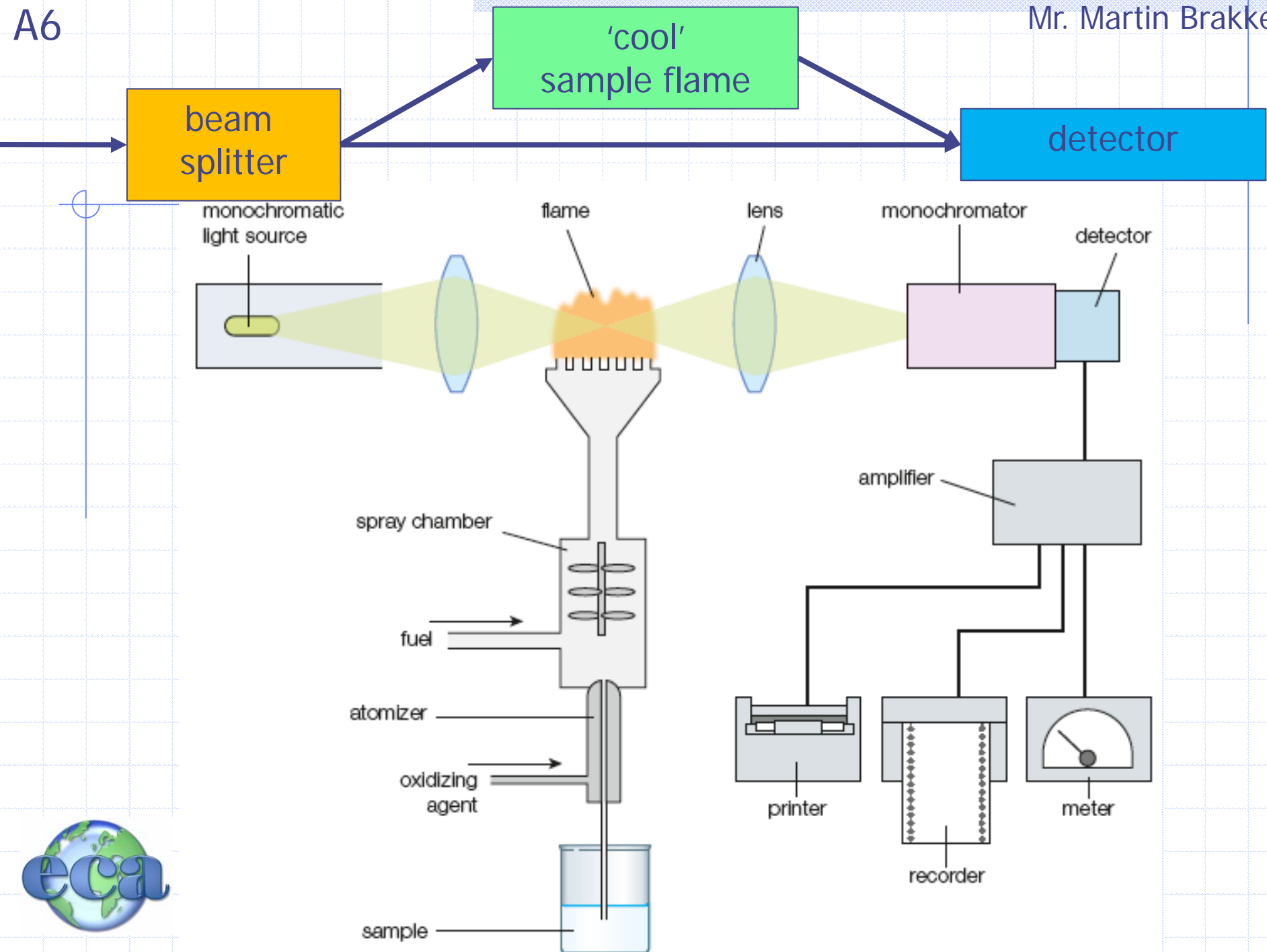


# Light Source and Detector

- Monochromatic Light Source and lens:
  - Use to focus a narrow beam of light (of a particular wavelength)
  - To ensure the absorption of particular elements, the source emitting radiation can be of that particular element. For example:
    - Excited Zn atoms can be used to produce light to analyze Zn by atomic absorption
  - The sensitivity is on the order of  $1 \times 10^{-6}$  ppm, that's 1 in 1,000,000,000,000 molecules can be identified!
- Monochromator detector:
  - Corrects for the background radiation from the flame (blank sample)
  - Background can also be scattered smoke particles or droplets
  - For elements with low I.E. there may be interference from ionization (alkali metals, etc)





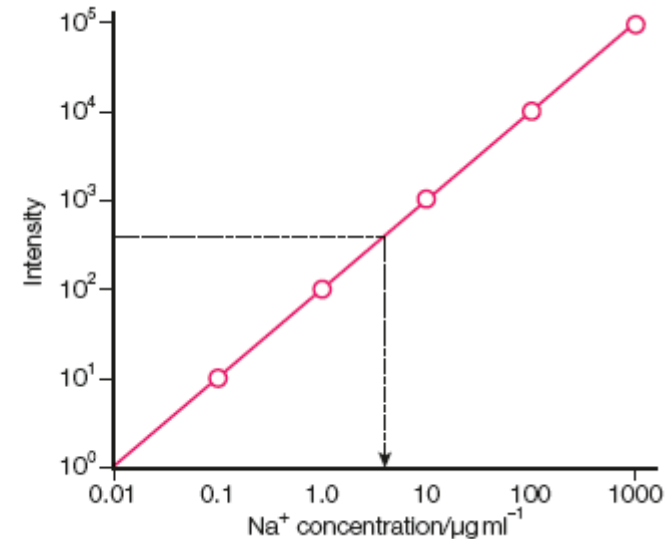




# Calibration Curves

## A.6.4 Determine the concentration of a solution from a calibration curve. (3)

- AAS measurements are made by using a previously prepared calibration curve and measuring the intensity of a selected emission line
- The calibration curve is used as in Beer's law and is prepared from standard solutions of known values of metal ions
- Acidic conditions are usually used to dissolve the metals (only those active metals will react)
- The following is a graph of the standard solutions of  $[\text{Na}^+]$  in blood plasma.



**Figure 21.77** A calibration graph of emission intensity versus concentration of sodium ions

